DOCUMENT RESUME

ED 353 128 SE 053 035

AUTHOR Madsen, Anne L.; Lanier, Perry E.
TITLE Improving Mathematics Instruction through the Role of the Support Teacher. Research Series No. 213.
INSTITUTION Michigan State Univ., East Lansing. Inst. for Research on Teaching.
SPONS AGENCY Department of Education, Washington, DC.
PUB DATE Apr 92
NOTE 38p.
AVAILABLE FROM Institute for Research on Teaching, 252 Erickson Hall, Michigan State University, East Lansing, MI 48824-1034 ($3.50).
PUB TYPE Reports - Descriptive (141) -- Tests/Evaluation Instruments (160)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Attitude Change; Educational Change; Elementary School Teachers; Inservice Teacher Education; *Instructional Improvement; Interviews; Junior High Schools; Learning Activities; Mathematics Curriculum; Mathematics Education; *Mathematics Instruction; *Program Descriptions; Secondary School Teachers; *Staff Development; Surveys; *Teacher Attitudes; Teacher Behavior; *Teacher Improvement; Teaching Methods
IDENTIFIERS Peer Coaching; Peer Supervision; *Support Teacher Program MI

ABSTRACT

The Support Teacher Program is a professional development program created to increase teachers' mathematical knowledge, improve instructional practices for conceptual understanding, and prepare teachers to conduct staff development activities in their schools with their colleagues. This paper is presented in three sections. The first section includes a description of this staff development model, the program goals, a description of the framework for guiding instructional and curricular changes, and the activities of the mathematics Support Teachers. The second section examines the impact of the program on the quality of mathematics instruction of three junior high school teachers who participated in the program. Data was gathered from the Teaching Style inventory, the Support Teacher Interview, and documentation of the Support Teachers' mathematics curriculum. Results indicated: (1) Each Support Teacher's thoughts and practices changed as a result of the program; (2) Support Teachers were adequately prepared for their new role by increasing their knowledge of and experience in effective instructional strategies and support techniques; (3) Teaching colleagues of the Support Teachers were influenced in varying degrees; and (4) Student results at the end of the first year indicated a more positive attitude towards mathematics, an improved ability to solve problems, and increased conceptual understanding. The third section includes comments on the Support Teacher Program. An appendix includes the Mathematics Support Teacher Reading List. (Contains 26 references.) (MDH)

ED353128

IRT
price
$3.50

Research Series No. 213

IMPROVING MATHEMATICS INSTRUCTION THROUGH THE ROLE OF THE SUPPORT TEACHER

Anne L. Madsen and Perry E. Lanier

BEST COPY AVAILABLE

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

X This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

Research Series No. 213

IMPROVING MATHEMATICS INSTRUCTION THROUGH THE ROLE OF THE SUPPORT TEACHER

Anne L. Madsen and Perry E. Lanier

Published by

The Institute for Research on Teaching
College of Education
Michigan State University
East Lansing, Michigan 48824-1034

April 1992

This work is sponsored in part by the Institute for Research on Teaching, College of Education, Michigan State University. The Institute for Research on Teaching is funded from a variety of federal, state, and private sources including the United States Department of Education and Michigan State University. The opinions expressed in this publication do not necessarily reflect the position, policy, or endorsement of the funding agencies.

Institute for Research on Teaching

The **Institute for Research on Teaching** was founded in 1976 at Michigan State University and has been the recipient of major federal grants. Funding for IRT projects is currently received from the U.S. Department of Education, Michigan State University, and other agencies and foundations. IRT scholars have conducted major research projects aimed at improving classroom teaching, including studies of classroom management strategies, student socialization, the diagnosis and remediation of reading difficulties, and school policies. IRT researchers have also been examining the teaching of specific school subjects such as reading, writing, general mathematics, and science and are seeking to understand how factors inside as well as outside the classroom affect teachers. In addition to curriculum and instructional specialists in school subjects, researchers from such diverse disciplines as educational psychology, anthropology, sociology, history, economics, and philosophy cooperate in conducting IRT research. By focusing on how teachers respond to enduring problems of practice and by collaborating with practitioners, IRT researchers strive to produce new understandings to improve teaching and teacher education.

Currently, IRT researchers are engaged in a number of programmatic efforts in research on teaching that build on past work and extend the study of teaching in new directions such as the teaching of subject matter disciplines in elementary school, teaching in developing countries, and teaching special populations. New modes of teacher collaboration with schools and teachers' organizations are also being explored. The Center for the Learning and Teaching of Elementary Subjects, funded by the U.S. Department of Education's Office of Educational Research and Improvement from 1987-92, is one of the IRT's major endeavors and emphasizes the teaching of elementary mathematics, science, social studies, literature, and the arts for understanding, appreciation, and use. The focus is on what content should be taught, how teachers concentrate their teaching to use their limited resources in the best way, and in what ways good teaching is subject-matter specific.

The IRT publishes research reports, occasional papers, conference proceedings, the Elementary Subjects Center Series, a newsletter for practitioners (IRT Communication Quarterly), and lists and catalogs of IRT publications. For more information, to receive a list or catalog, and/or to be placed on the IRT mailing list to receive the newsletter, please write to the Editor, Institute for Research on Teaching, 252 Erickson Hall, Michigan State University, East Lansing, Michigan 48824-1034.

Co-directors:	Jere E. Brophy and Penelope L. Peterson
Senior Researchers:	Janet Alleman, Tane Akamatsu, Charles Anderson, Linda Anderson, Betsy Becker, Margret Buchmann, Patricia Cianciolo, Gerald Duffy, Carol Sue Englert, James Gallagher, James Gavelek, Sandra Hollingsworth, Magdalene Lampert, Perry Lanier, Wanda May, Annemarie Palincsar, Richard Prawat, Ralph Putnam, Taffy Raphael, Stephen Raudenbush, Laura Roehler, Cheryl Rosaen, Kathleen Roth, Pamela Schram, John Schwille, David Stewart, M. Teresa Tatto, Mun Tsang, Christopher Wheeler, Suzanne Wilson
Editor:	Sandra Gross
Editorial Assistant:	Tom Bowden

Abstract

This paper describes a professional development program that established a new role for junior high school mathematics teachers--the Support Teacher. The program was a collaborative effort of the American Federation of Teachers, Michigan State University, and Toledo Public Schools. The Support Teacher Program began in 1987 and continued through 1992. It is directed by Perry E. Lanier and James J. Gallagher from Michigan State University. Eight junior high school mathematics and science teachers participated with Lanier and Gallagher to implement the Support Teacher Program. As a result of their participation in the Support Teacher Program, the teachers changed their thinking about learning and instruction. This paper describes the activities of the mathematics Support Teachers and discusses the results of interview, survey, and documentation data.

IMPROVING MATHEMATICS INSTRUCTION THROUGH THE ROLE OF THE SUPPORT TEACHER

Anne L. Madsen and Perry E. Lanier[1]

Many students leave high school lacking the mathematical understanding which will allow them to participate fully as workers and citizens in contemporary society. Recent reports indicate students lack sufficient understanding of necessary mathematical concepts. The results from the National Assessment of Educational Progress in mathematics (Dossey, Mullis, Lindquist, & Chambers, 1988) show that while most students were able to compute, the majority did not understand many basic mathematical concepts and were unable to apply the skills they had learned to simple problem solving situations. Low levels of achievement and the lack of conceptual understanding influence students' interest in and attitude toward mathematics.

> Mathematics is a useful, exciting, and creative area of study that can be appreciated and enjoyed by all students in Grades 5-8. . . . However, many students view the current mathematics curriculum in Grades 5-8 as irrelevant, dull, and routine. Instruction has emphasized computational facility at the expense of a broad, integrated view of mathematics and has reflected neither the vitality of the subject nor the characteristics of the students. (National Council of Teachers of Mathematics [NCTM], 1989, p. 65)

Recent research on mathematics learning and instruction in concert with national efforts to reform school mathematics have called for changes in the curriculum and instruction of school mathematics. Advocates of such changes have suggested implementing a more conceptual approach in teaching mathematics (Dossey et al., 1988; Mathematical Sciences Education Board & the National Research Council [MSEB], 1990; NCTM, 1989). Adopting a conceptual approach in junior high school mathematics requires instructional and curricular changes. In spite of the recognized need to change beliefs about learning and instruction (Holmes Group, 1986), recent studies of mathematics education have noted that procedurally oriented instruction prevails in most classrooms today (Crosswhite, Dossey, Swafford, McKnight, & Cooney, 1985;

---

[1]Anne L. Madsen, assistant professor in the Department of Curriculum and Instruction at The University of Texas in Austin, is a senior researcher with the Support Teacher Project. Perry E. Lanier, professor of teacher education at Michigan State University, is a senior researcher with the Project.

Dossey et al., 1988; McKnight, Crosswhite, & Cooney, 1987). Specifically, the National Research Council (1989) characterized such traditional practice as "lecturing and listening."

> Despite daily homework, for most students and most teachers mathematics continues to be primarily a passive activity: teachers prescribe; students transcribe. Students simply do not retain for long what they learn by imitation from lectures, worksheets, or routine homework. Presentation and repetition help students do well on standardized tests and lower-order skills, but they are generally ineffective as teaching strategies for long-term learning, for higher-order thinking, and for versatile problem-solving. (p. 23)

Providing students with the opportunity to achieve levels of excellence in mathematics requires significant improvement of the instruction that currently exists. Recent educational reports, such as those by the NCTM (1980, 1989), the Holmes Group (1986), and the Carnegie Forum on Education and the Economy (1986) recognized the critical need for instructional improvement as a significant dimension of educational reform.

The Support Teacher Program

The Support Teacher Program established a professional development environment for extended interactions among educational personnel. Built around the concept of teacher as instructional leader, the position of Support Teacher provided a mechanism for developing local experts who possessed the skills and knowledge around which productive interactions with colleagues occurred. It was also a vehicle for creating an environment in which teachers assisted one another in self-appraisal and self-improvement to the benefit of all their students. Through this role, Support Teachers and their colleagues became better prepared to teach mathematics, became more highly motivated, and shared a collective commitment to the teaching profession.

Theoretical Model

The program was created to increase teachers' mathematical knowledge, improve instructional practices, and prepare teachers to conduct staff development activities in their schools with their colleagues. To achieve this, a new staff development model was developed which contained the components of three staff development models: developmental model (Andrews, Houston, & Bryant, 1981; Glassberg & Oja, 1981; Knowles, 1984; Oja, 1980; and Tallerico, 1987), the linking-agent model (Carlson, 1965; Caruso, 1985; Havelock, 1968;

Howsam, 1967; and Seiber, Louis, & Metzger, 1972) and the peer-coaching model (Joyce & Showers, 1988; Showers, 1983a, 1983b, 1985a, 1985b). Features of the Support Teacher Program's staff development model included the following goals:

1. Collaboration of school personnel, union officials, and university-based researchers
2. Use of results, conclusions, and implications of extensive research on teaching including studies of actual classroom actions
3. Establishment of a professional role in schools and preparing junior high school mathematics teachers to work in schools in a new role as exemplary practitioners and leaders in professional development activities
4. Production of a framework for introducing and implementing improvements in classroom practice

The purpose of the program was to improve the opportunities of students' access to the understanding of mathematics. The means of attaining this were through (a) implementation of instructional changes in the Support Teachers' own classes and (b) creation of collegial working relationships among the mathematics faculties that supported instructional improvement changes, experimentation, reflection, and peer interaction in and out of the classroom.

The Framework for Guiding Instructional and Curricular Changes

The work of the Support Teachers focused on improvement of their own instruction and that of their colleagues. The Support Teachers studied recommendations from research and literature on improving mathematics education. A listing of the readings is in the Appendix. The Curriculum and Evaluation Standards for School Mathematics (NCTM, 1989; Curriculum Standards hereafter) and the Professional Standards for Teaching Mathematics (NCTM, 1991; Professional Standards hereafter) were used by the Support Teachers to plan curricular and instructional changes. These changes centered around the idea of teaching mathematics from a different viewpoint.

> The teaching of mathematics is shifting from an authoritarian model based on "transmission of knowledge" to a student-centered practice featuring "stimulation of learning." The teaching of mathematics is shifting from preoccupation with inculcating routine skills to developing broad-based mathematical power. (MSEB, 1990, p. 5)

Results from the Second International Mathematics Study (Dossey et al., 1985) portrayed mathematics instruction as procedurally oriented--this is the traditional instruction observed typically in most junior high school classrooms. The Support Teachers used the categories for

teaching mathematics from the Professional Standards (NCTM, 1991) to plan and implement changes in their instruction that reflected nontraditional, student-centered practice. The categories include

- Worthwhile Mathematical Tasks
  Tasks are the projects, questions, problems, constructions, applications, and exercises in which students engage.
- Discourse
  Discourse refers to the ways of representing thinking, talking, and agreeing and disagreeing that teachers and students use to engage in those tasks.
- Environment
  Environment represents the setting for learning. It is the unique interplay of intellectual, social, and physical characteristics that shapes the ways of knowing and working that are encouraged and expected in the classroom.
- Analysis of Teaching and Learning
  Analysis is the systematic reflection in which teachers engage. It entails the ongoing monitoring of classroom life--how well the tasks, discourse, and environment foster the development of every student's mathematical literacy and power.

Much of the Support Teachers' time and efforts the first year were spent in implementing instructional improvements in their mathematics classes. In the second year of the Support Teacher Program more time was spent helping their colleagues implement these same improvements.

Activities of the Mathematics Support Teachers

During the fall of 1987, four mathematics teachers were selected by their peers and administrators from each of four Toledo, Ohio, junior high schools to participate in the Support Teacher Program. From February to August 1988, they were given over 60 hours of intensive preparation that included (a) updating their knowledge about current research on teaching and learning mathematics and (b) providing background and guided practice in working with professional peers in a supportive role.

The administration of each school provided the Support Teacher with a half-day instructional release time for support activities. The Support Teachers attended meetings with Michigan State University staff and participated in reviewing and discussing selected literature related to curricular and instructional improvements. The teachers attended an intensive

summer program at MSU where they planned support activities for the 1988-89 academic year.

After the first year, each Support Teacher had created a role unique to his/her own situation. There were, however, some common characteristics, such as conducting regular Support Teacher meetings and reviewing literature related to mathematics education, learning, and instruction. Some Support Teachers worked actively in classrooms with their colleagues, observed instruction, and provided feedback. Each Support Teacher was responsible for implementing instructional improvements in his/her own classroom. This was a difficult task and one which took longer than a year to accomplish. The MSU staff met with the Support Teachers on a monthly basis in their schools and assisted them with instructional improvements. Of the four teachers who started in the program, three remained for the second year. One Support Teacher discontinued participation in the program and was replaced by another teacher.

During the second year, the activities of the Support Teachers and the MSU staff continued. The Support Teachers (a) observed classes taught by other mathematics teachers; (b) provided constructive feedback to the teacher observed; (c) conducted meetings with their colleagues about instructional improvements; (d) studied current literature on teaching and learning mathematics; and (e) maintained informal contacts with their colleagues and school administrators about the issues of the Support role.

The Question Guiding the Inquiry and the Data Collected

The question guiding this inquiry was, "What is the nature and degree of change in the quality of mathematics instruction given this restructured staffing pattern?" Four kinds of data were collected: (a) documentation of technical assistance by the MSU staff; (b) observation and documentation of the activities and events of Support Teaching by outside observers; (c) interview; and (d) survey. Survey and documentation data were also collected on the colleagues of the Support Teachers, and the results will be reported in another paper.

Preliminary Results and Outcomes of the Support Teacher Program

Results from the Teaching Style Inventory (a survey), the Support Teacher interview, and documentation of the Support Teachers' mathematics curriculum suggested changes took place in the thoughts and practices of the mathematics teachers. Analysis of the data added confirmatory evidence for the benefits of this extended professional role for mathematics teachers. The results included the following items:

1. Each Support Teacher's thoughts and practices changed as a result of the program. Instruction became less traditional in nature, more concept-oriented, activity-based, and focused on problem solving.
2. The activities of the program adequately prepared Support Teachers for their new role by increasing their knowledge of and experience in effective instructional strategies and support techniques.
3. The teaching colleagues of the Support Teachers were influenced in varying degrees. Some colleagues greatly improved their thoughts and practices while others made moderate changes. There were some colleagues at every school who resisted change altogether.
4. At the end of the first year of the program, the student results (from tests, written work, and verbal comments) indicated a more positive attitude towards mathematics, an improved ability to solve problems, and increased conceptual understanding.

The Teaching Style Inventory

The Teaching Style Inventory was given to the Support Teachers to learn about their thoughts regarding instructional practices, student learning, and the nature of the mathematical content in the curriculum. Examples of some questions for Parts I and II are included in Figure 1.

The Teaching Style Inventory was administered to the Support Teachers four times during the first year-and-a-half: (a) at the start of the program; (b) after four months; (c) following a summer workshop; and (d) at the end of the first school year. Analysis of the results suggest the following points:

1. The teachers had changed their thoughts about teaching mathematics. They moved from a transitional view of teaching and learning to a more nontraditional view.
2. During the teachers' involvement in the program, their thoughts changed at different rates. Some teachers changed their thinking before others did. The greatest range of scores occurred during the second survey.
3. By the fourth survey, the responses of all the teachers were thinking more alike in nontraditional ways.

PART I CLASSROOM PROCEDURES

Check the point within each of the following scales which most accurately describes your math class.

2.	When students have trouble, I ask them leading questions.	_____1
		_____2
		_____3
		_____4
	When students have trouble, I explain how to do it.	_____5
4.	In class, students frequently work together on assignments.	_____1
		_____2
		_____3
		_____4
	Students seldom work together on assignments in class.	_____5
6.	I encourage students to solve a given math problem the way I have demonstrated.	_____1
		_____2
		_____3
	I encourage students to solve math problems in a variety of ways.	_____4
		_____5
7.	I present a math concept first then illustrate that concept by working several problems (deductive).	_____1
		_____2
	I present the class with a series of similar problems then together we develop concepts and methods of solving the problems (inductive).	_____3
		_____4
		_____5
11.	In my math class I emphasize the basic computational skills three-fourths of the time or more.	_____1
		_____2
		_____3
	In my math class I emphasize concept development three-fourths of the time or more.	_____4
		_____5
14.	Almost all my questions in math class can be answered with yes, no, or a number.	_____1
		_____2
		_____3
	Almost all my questions in math class require the students give explanations.	_____4
		_____5

Figure 1. Mathematics Teaching Style Inventory (selected items).

PART II: INSTRUCTIONAL STRATEGIES

How frequently do you use the strategy in your class?

	Very Frequently	Frequently	Sometimes	Seldom	Never
18. Whole class instruction	○	○	○	○	○
19. Whole class discussion	○	○	○	○	○
20. Posing open-ended challenges	○	○	○	○	○
21. Gathering and organizing student responses	○	○	○	○	○
22. Encouraging analysis and generalization	○	○	○	○	○
23. Assigning homework	○	○	○	○	○
24. Discussing homework	○	○	○	○	○
25. Using concrete manipulatives	○	○	○	○	○
26. Using games	○	○	○	○	○
27. Drills	○	○	○	○	○
28. Story problems	○	○	○	○	○
29. Nonroutine problems	○	○	○	○	○

Figure 1 (contd).

Analysis of the Teaching Style Inventory

The Teaching Style Inventory consisted of four parts of which two were used in this analysis: Part I (Classroom Procedures) and Part II (Teaching Strategies). The method of analysis compared the teacher's actual response with an ideal response for each item. The ideal response reflected a student-centered, concept-oriented, nontraditional instructional approach as recommended in the Curriculum Standards (NCTM, 1989) and the Professional Standards (NCTM, 1991). If a teacher's actual response on an item was **2**, and the ideal response was **5**, the difference (absolute value) of **3** was recorded. A sum of the differences for all the items was calculated for each survey. The difference between the sum on the first and last survey represented the amount of change which occurred. **The lower the number, the closer the teacher's actual responses were to the ideal**. A total score of **0-28** on the mathematics inventory indicated responses close to the ideal. This score suggests a nontraditional instructional approach. A total score of **84-112** indicated responses that represented a more traditional instructional approach. The results of the four surveys for each teacher are presented in Table 1 and Figure 2.

Discussion of the Results on the Teaching Style Inventory

The results of the Teaching Style Inventory indicate that the mathematics Support Teachers had changed their thinking about instruction and learning. They had changed from a more traditional to a more nontraditional approach. They had incorporated many of the recommendations from both of the NCTM Standards into their instruction. Although the teachers had changed their thinking, they were not able to implement simultaneously a nontraditional instructional approach in their classes. This was a point of frustration for each Support Teacher--knowing what to change and not being able to accomplish it as fast and with as much success as they would have liked.

The Support Teacher Interviews

The interview questions focused on the tasks, discourse, and the environment--categories of instructional improvement identified in NCTM's Professional Standards (1991) and

Curriculum Standards (1989). The Support Teachers were interviewed four times: (a) March 1988; (b) September 1988; (c) June 1989; and (d) May 1990. (For the list of interview questions, see Figure 3.)

Analysis of the Teacher Interviews

An instrument was developed to measure the degree to which the teachers' thoughts reflected traditional or nontraditional instructional approach. Three categories were used to analyze the teachers' responses--content (tasks), communication patterns (discourse), and the learning environment. The three categories in the NCTM Professional Standards (1991) identified the optimal level by which the teachers responses were measured.

The three categories were used to analyze the teachers' responses. A level 3 response in a category represented a traditional instructional approach, a level 1 response characterized the nontraditional instructional approach, and a level 2 response indicated instructional thoughts that were improved from level 3 but not yet optimal (as in level 1).

The Content of the Mathematics Curriculum. This category included the orientation of the content, topics that were covered, the tasks which were selected, and how learning was evaluated. The category "Worthwhile Mathematical Tasks" in the Professional Standards (NCTM, 1991, p. 25-32) is related to practice at response level 1 in this category. Interview questions 1, 6, 10, and 13 were in this category. The three levels in this category are described in Figure 4. This is followed by segments from the first and last interview with Wilma Burns[2] which depict her thoughts about the mathematical content and curriculum.

Wilma Burns was asked, "What are the big ideas in 7th/8th-grade mathematics?" Her responses, listed below, are from the first and last interview.

> March 1988
> It is the last time they will have to learn mathematics. It is covering the basics--add, subtract, multiply, divide, and problem solving. That is why I let them use calculators.
> May 1990
> Number theory, rational numbers, decimals, percents, and linking them together. Probability and statistics, problem solving that is integrated into the curriculum,

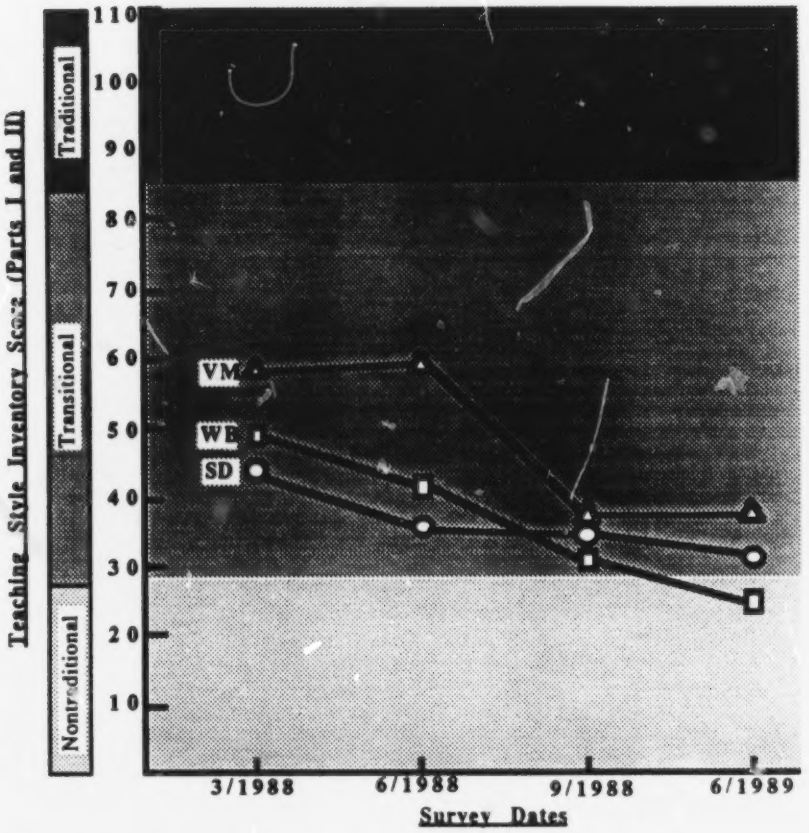
[2]Names of all teachers are pseudonyms.

Table 1

Results of the Teaching Syle Inventory

	Teaching Style Inventory: Parts I and II				
Support Teachers	3/88	6/88	9/88	6/89	Change (3/88 to 6/89)
Wilma Burns	47	42	31	25	Δ 22
Susan Day	43	36	35	31	Δ 12
Vance Martin	58	59	37	38	Δ 20

Note: An ideal score is from 0 to 28.



VM - Vance Martin
WB - Wilma Burns
SD - Susan Day

Figure 2. Results of the Teaching Style Inventory.

1. What are the big ideas in _____grade _____mathematics?

2. (a) How do you know when a class period is/is not going well?
   (b) Describe a class period that you thought went well recently.

4. (a) What motivates your students to learn the content?
   (b) What motivates your students to complete their assignments?

6. How important is practice in your classes?

7. One frequently hears the statement, *"It is important that students understand the content."*
   (a) What does that mean to you?
   (b) How do you know when students do not understand the content?

9. What characteristics do you like to see in your students? What characteristics do you like to see in your classes?

10. How would you describe your role as teacher?

11. What is your interpretation of the Support Teacher role?

12. What would improve the learning opportunities for your students?

13. What improvements would you suggest on a school-wide basis?

14. How do you assess the Support Teacher Program activities so far?

Figure 3. Interview questions.

LEVEL 1: Nontraditional	LEVEL 2: Transitional	LEVEL 3: Traditional
Concept orientation with linkages to other content or topics.	Concept orientation with no linkages to other content or topics.	Procedural/computational orientation.
Topics/units focus on unifying concepts.	Familiar topics/units set in a new context.	Topic-centered curriculum.
Tasks are interesting/challenging and engage students in active experiences that enhance conceptual understandings.	Tasks are interesting although routine and focus on the concept studied.	Tasks are routine and used to develop skills.
Evaluation includes paper & pencil tests, interviews, and observations focused on conceptual understandings.	Evaluation consists of paper & pencil tests which measure procedural and concept understandings.	Evaluation consists of paper & pencil tests to measure procedural knowledge.

Figure 4. Levels of mathematical content.

and geometry. My changes in thinking over the year has been in establishing linkages and requiring less memorization.

In the first interview, Wilma Burns describes a mathematics curriculum that represents a traditional approach. By the last interview her thinking had changed. She now viewed the content of the mathematics curriculum very differently. Her focus is on mathematical concepts and the connections made between units of content. This change was also observed in Wilma's classroom instruction. Similar changes occurred in the responses of the other Support Teachers.

The Patterns of Communication. The next category considered the communication in the classroom. Contained in this category were the ways in which a teacher questioned, explained, and discussed mathematics with the students and the degree to which students were encouraged to participate. The category of "Discourse" in the Professional Standards (NCTM, 1991, p. 35-56) relates practice at level 1 in this category. Interview questions 7, 10, and 12 are in this category. A description of the three levels of communication is presented in Figure 5. What follows are Susan Day's first and last interview responses to a question related to communication and student understanding.

Susan Day was asked, "One frequently hears the statement, 'It is important that students understand the content.' (a) What does that mean to you? and (b) How do you know when students do not understand the content?" She responded as follows:

March 1988
(a) It means more than the ability to do an operation. It should mean seeing a lot more about a particular problem. It's more than what's in the book. (b) By their responses--the students will verbalize to me that they don't understand. Sometimes I give them a couple of problems and I can get around the class to see if they have problems.
May 1990
It has come to mean that the students can use and apply what they have learned to various situations. That they have various ways to see and solve problems. It means that they don't just have one way to see things. Understanding is not just remembering memorized rules. The students need to know why they are doing what they are doing.

Susan's responses include references to the importance of communicating with students in order to learn about their understanding. Susan Day had changed her thoughts about student

learning and the importance of communication. In the first interview, understanding means how successful the students were in computing answers to problems or by results on a test or quiz. In the last interview, understanding is assessed through discussions of the concepts or by the students' application of the concepts to new situations.

The Social Organization and the Learning Environment. This category considered the ways in which teachers organized students for learning; encouraged learning and organized the curriculum; and spent instructional/class time. The category the "Environment" in the Professional Standards (NCTM, 1991, p. 57-62) reflects instructional practice at level 1 in this category. Interview questions 2, 4, 9, 10, 12, and 13 are related to this category. Figure 6 describes the levels in this category.

In the first and last interviews, Vance Martin talked about classes that "went well" and those that didn't. He also talked about classes that he thought "went well."

> March 1988
> (a) When there are a lot of distractions in the class--when people are not focusing on the lesson. They are not attending to what is going on. It may mean they are bored. (b) Last week the thing I did with this class was mixed numbers and it was a learning situation. We divided up into groups of 4 and each person was responsible for doing one part of a *division of mixed numbers* problem. We set it up as a competition. I was pleased because I thought they understood the concept of the problem better.
> May 1990
> When the kids have too many questions, then I don't think they really understand what their task is supposed to be. If they do keep asking questions when they understand the task, then they are asking questions of the nature that they want you to do the work for them. You've got to turn that into a situation where they can do the work. You can do that by either not helping them or by asking them their own questions back. I want them to be actively involved and I want them to have more input into the class because they are interacting with each other for instructional purposes, not socialization. When the class is going well the kids help each other, ask each other questions.

In the first interview, Vance believes a class didn't go well when students were off task or seemed bored. By the last interview his attitude and thinking had changed. He felt at that time a lesson didn't go well when the students asked a lot of questions because they didn't understand. In general, by the last interview the Support Teachers' judgment of whether a class went well focused on lack of student understanding rather than on their off-task behavior.

LEVEL 1: Nontraditional	LEVEL 2: Transitional	LEVEL 3: Traditional
Instruction is guided discovery with active student participation.	Instruction is mostly demonstration with limited student participation.	Instruction is demonstration without student participation.
Teacher's questions are open-ended and require students to provide an explanation. Controlled practice is used to promote student understanding.	Teachers questions require students to give some explanation.	Teacher's questions require one-word responses from students.
Explanations embellish and enrich the concept/idea being studied.	Teacher's explanations focus on some concepts or procedures.	Teacher's explanations focus on procedures or definitions.
Discussions are interesting, meaningful and students actively initiate thoughts, conjectures and ideas.	Discussions are focused on concepts, but students don't initiate the ideas.	Discussions are limited to the development of a skill, definition or procedure.
Feedback is specific and related to the students' understanding of the concept or idea.	Feedback is concept-related, but not focused on student understanding.	Feedback is used to keep students on task.

Figure 5. Levels of patterns of communication.

LEVEL 1: Nontraditional	LEVEL 2: Transitional	LEVEL 3: Traditional
Cooperative groupings are used and the activities promote the development of concept understanding.	Students work occasionally in groups, but tasks are not developed purposefully for the groups.	Students are expected to work individually on their tasks.
Concrete manipulatives, illustrations, and activity-based experiences are used to help students understand the concepts being studied.	Concrete manipulatives and illustrations are demonstrated by the teacher to help students better understand the concepts.	Manipulatives and illustrations are not used or are used in ways that promote student understanding of the content.
The curriculum integrates concepts and ideas through strands which connect and unify units of content.	The curriculum is changing to reflect concepts and ideas. The teacher is relying less on the textbook for curriculum planning.	The curriculum is textbook-bound and fragmented into unrelated units and topics.
Students are engaged in content-related activities before and after the lesson.	The teacher inconsistently plans for students to work on a task before or after the lesson.	Students spend time socializing before and after the lesson.

Figure 6. Levels of the learning environment.

Results of the Analysis of the Support Teacher Interviews

The teachers' responses were analyzed using the categories to identify the level of their response for each question. Their responses were assigned a level (1, 2, or 3) and then compared across the four interviews. Each teacher's levels of responses for the four interviews are included in Figures 7, 8, and 9.

A total score was obtained for each interview. This was the sum of the levels of the responses for each interview. A level 1 represented a student-centered, concept-centered, nontraditional orientation. Since 11 questions were analyzed in each interview, the total score for the responses of the interviews should move in the direction of the ideal total score of 11. Table 2 and Figure 10 represent the total scores for the Support Teachers across the four interviews.

Discussion of the Support Teacher Interview Results

The results suggest that (a) the mathematics Support Teachers had changed their thoughts about teaching and learning; (b) they moved from a traditional to a nontraditional orientation by the last interview; and (c) none of the Support Teachers had reached a nontraditional orientation until the end of the second year.

The teachers had changed their thoughts about the content, communication, and the classroom environment. These results supported the findings of the Teaching Style Inventory. By June 1989, the interview and survey results indicate they were in a transitional level of thinking. By May 1990, the interviews show they moved to a nontraditional orientation. Of particular importance was the finding that their thinking changed gradually and evolved over time. While their thinking had changed over the two-and-a-half years, their practice had not yet reached the nontraditional level. None of the teachers felt completely successful in implementing all the improvements they planned. Results from research noted that changing teacher practice would indeed take longer than changing their thinking. (Madsen-Nason, 1988)

Changes in the Support Teachers' Mathematics Curriculum

The Support Teachers described their mathematics curriculum in 1986-1987, before their participation in the program, and for 1990-1991. Analysis of their self reports indicate the nature of the content and the curriculum had changed. Figures 11, 12, and 13 are the mathematics curricula of the Support Teachers.

The Support Teachers had changed their curricula from 1986-87 to 1990-91. Even though they taught different grades and content, there were similarities in changes they made. First, more time was now spent in studying larger mathematical units. Second, each 1990-91 curriculum was less fragmented than the 1987-88 curriculum. The teachers all reported trying to build a curriculum that focused on big ideas or concepts and that made mathematical connections between units of content. Furthermore, the teachers implemented new units from outside their textbooks which were student-centered and activity-based.

Comments on the Support Teacher Program

The Support Teacher Program provided the opportunity for teachers to improve the quality of their mathematics instruction and to work with colleagues to improve learning and instruction at a department level. Evidence from interviews, surveys, and documents indicate that the changes which took place in the thoughts and practices of the Support Teachers evolved gradually. Even after two-and-a-half years, the Support Teachers were still working to implement changes in their instructional practice. Some teachers had just begun to use cooperative learning strategies, others started to construct a cohesive and concept-oriented curriculum, and others focused attention on strengthening the communication patterns in their classes. All the Support Teachers continued to work with their colleagues.

Indeed, Support Teachers reported their students responded positively to new techniques and instructional ideas they implemented. Moreover, they demonstrated increased confidence and competence, which resulted from interactions with their colleagues and from being engaged in significant professional growth activities. Teachers and students alike benefited from the

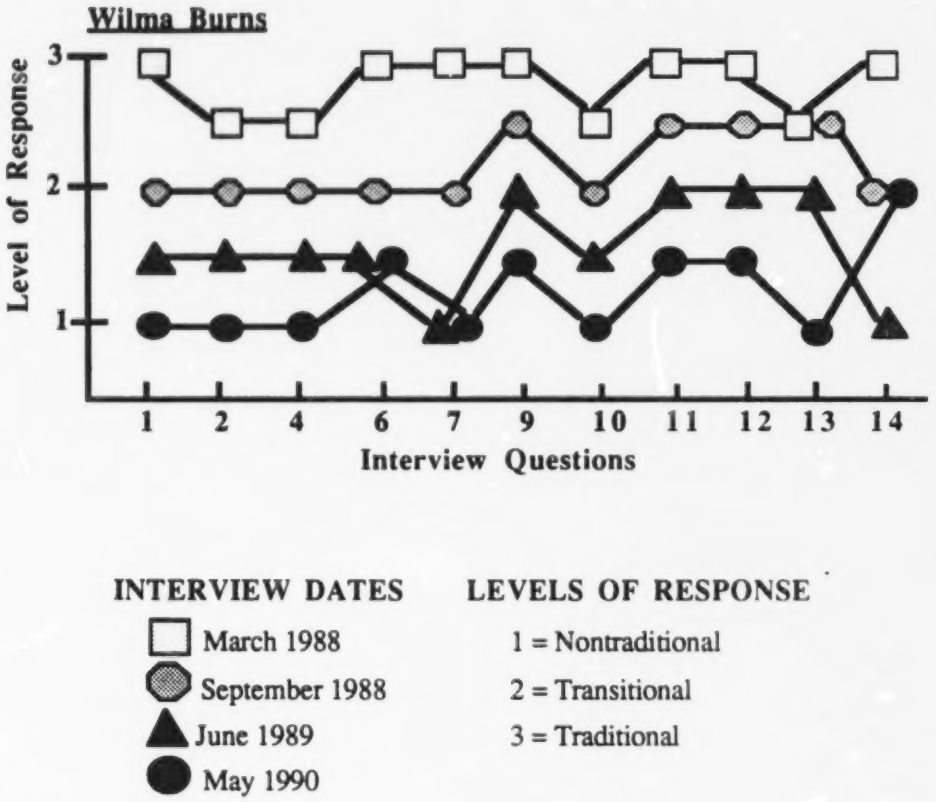


Figure 7. Levels of responses to interview questions: Wilma Burns.

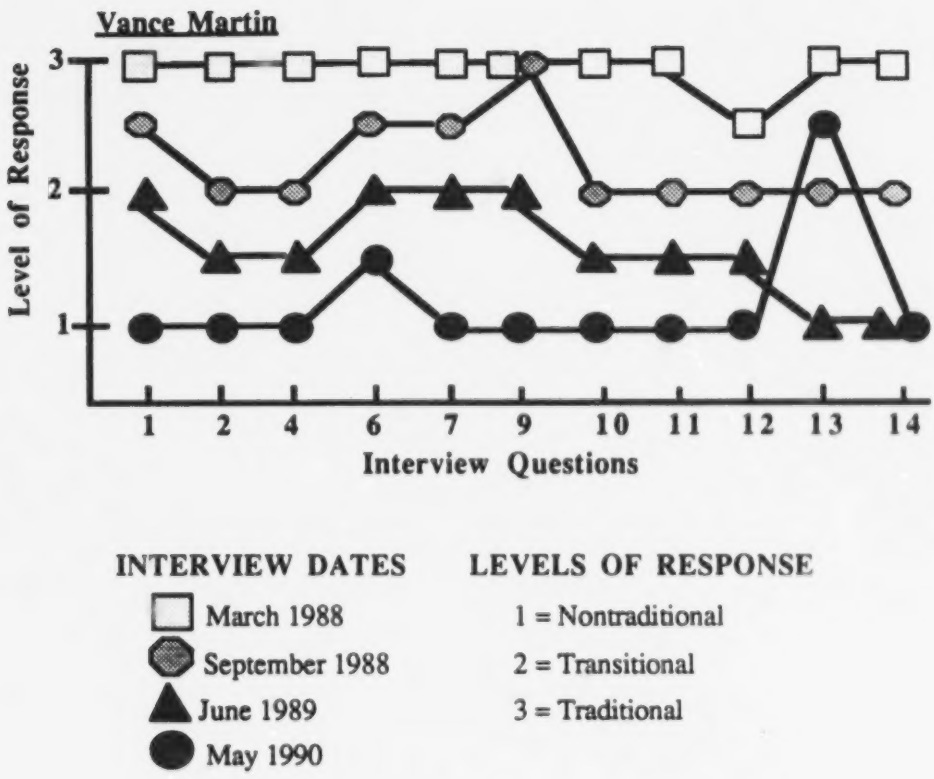


Figure 8. Levels of responses to interview questions: Vance Martin.

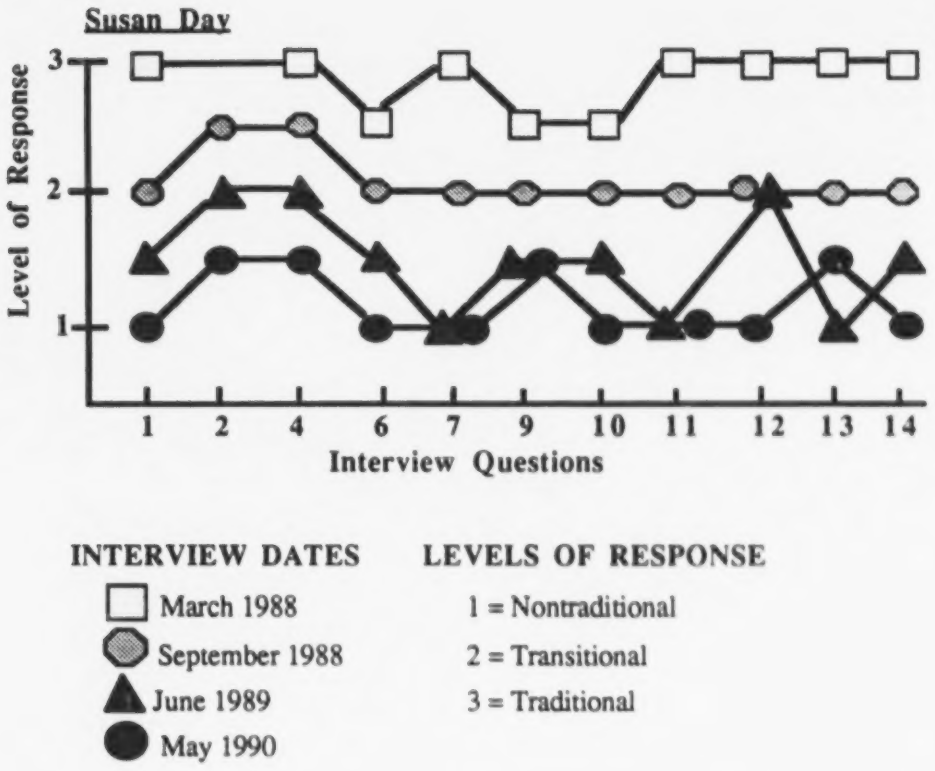


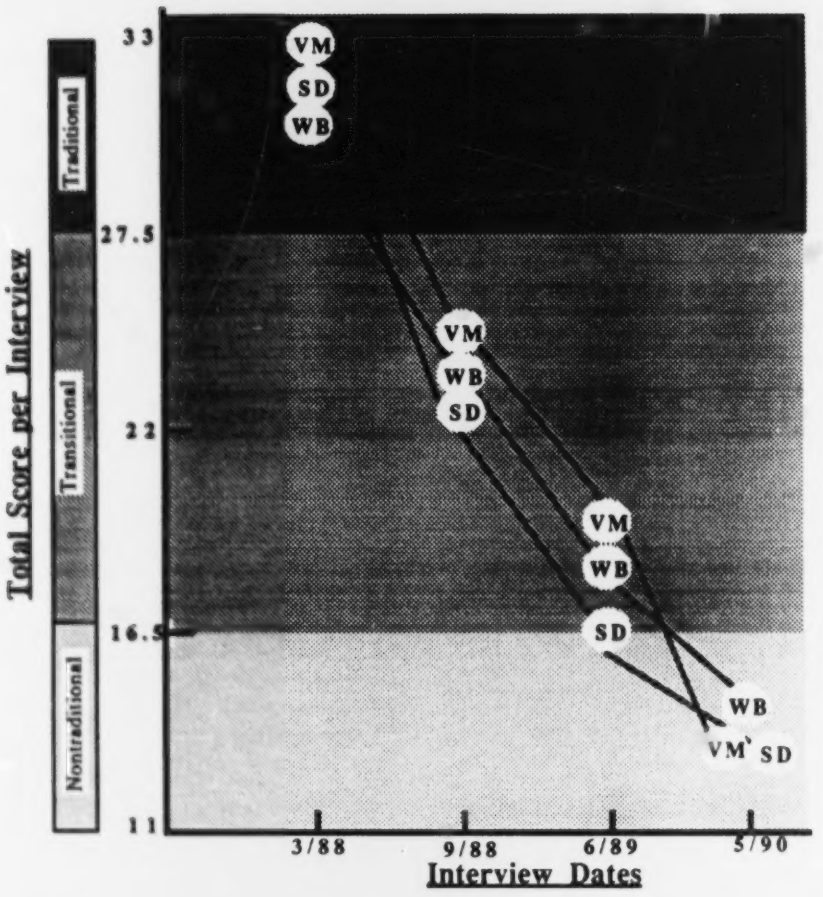
Figure 9. Levels of responses to interview questions: Susan Day.

Table 2

Levels of Responses of the Support Teacher Interviews

	Support Teacher Interview Results				
Support Teachers	3/88	9/88	6/89	5/90	Change (3/88 to5/90)
Wilma Burns	31	24	17.5	14	Δ 17
Susan Day	31.5	23	16.5	13	Δ 18.5
Vance Martin	32.5	24.5	18	13	Δ 19.5

Note: A Level 1 (Nontraditional) score is from 11 to 16.5.
A Level 2 (Transitional) score is from 17 to 27.5.
A Level 3 (Traditional) score is from 28 to 33.



VM - Vance Martin
WB - Wilma Burns
SD - Susan Day

Figure 10. Levels of responses of the mathematics Support Teachers' interviews.

1986-1987	
TOPIC	WEEKS
Whole Nos. & Operations	4
Number Theory	1 1/2
Fractions	5
Decimals	3
Equations	3
Geometry	4
Ratios	1 1/2
Percents	4
Perimeter, Area, Volume	4
Integers	3
Real Numbers, Coordinate Plane	3

1990-1991	
TOPIC	WEEKS
Probability*	6
Integers	3
Fractions	7
Measurement Using Fractions	2
Mouse & Elephant* & Textbook Area & Volume	7
Equivalency (Decimals, Proportion, %)	5
Informal Equations	2
Measurement (Metric)	2
Spatial Visualization*	2
Problem Solving	daily

*Middle Grades Mathematics Project Unit, Addison-Wesley Publications

Figure 11. Wilma Burns's mathematics curriculum.

1986-1987	
TOPIC	WEEKS
Whole Numbers & Operations	3 1/2
Integers	3
Exponents & Powers of Ten	4
Decimals	3 1/2
Percents	4
Fractions	6
Equations	3
Coordinate Graphing	4
Geometry	4
Metric Measures	3

1990-1991	
TOPIC	WEEKS
Integers	2
Mouse & Elephant *	7
Factors & Multiples *	7
Fractions, Decimals, Percents	5
Equations & Graphing	4
Probability & Statistics	4
Problem-Solving Strategies	9

*Middle Grades Mathematics Project Unit, Addison-Wesley Publications

Figure 12. Vance Martin's mathematics curriculum.

7th Grade

1986-1987	
TOPIC	WEEKS
Problem-Solving Strategies	1
Whole Numbers	4
Decimals	3
Patio, Proportion, Percent	4
Number Theory	2
Fractions	4
Measurement	2
Geometry (Angles, Polygons)	3
Perimeter, Area, Volume	4
Integers	1

1990-1991	
TOPIC	WEEKS
Problem-Solving Strategies	4
Decimals	4
Factors & Multiples*	4
Fractions	7
Ratio, Proportion, Percent	5
Similarity*	4
Geometry (Angles, Polygons)	3
Spatial Visualization* Part I	1
Integers	2

*Middle Grades Mathematics Project Unit, Addison-Wesley Publications

8th Grade

1986-1987	
TOPIC	WEEKS
Whole Numbers	3
Decimals	3
Number Theory	2
Fractions	4
Equation Solving	3
Geometry	3
Ratio, Proportion, Percent	3
Measurement	1
Perimeter, Area Volume	3
Integers	2
Rational Numbers	2
Graphing	2
Geometry	2

1990-1991	
TOPIC	WEEKS
Review	2
Problem-Solving Strategies	4
Mouse & Elephant*	4
Probability *	4
Statistics	4
Spatial Visualization * Part II	1
Geometry (Trigonometry, Pythagorean Theorem, Right Triangles, Similarity)	3
Algebra (Integers, Equations Graphing, Misc.)	10

*Middle Grades Mathematics Project Unit, Addison-Wesley Publications

Figure 13. Susan Day's mathematics curriculum.

new professional role that kept these exemplary teachers in the classroom and extended their influence to other teachers.

References

Andrews, T.E., Houston, W.R., & Bryant, B.L. (1981). Adult learners: A research study. Washington, DC: Association of Teacher Educators.

Carlson, R.O. (1965). Adoption of educational innovations. Eugene: University of Oregon, Center for the Advanced Study of Educational Administration.

Carnegie Forum on Education and the Economy. (1986). A nation prepared: Teachers for the 21st century. New York: Author.

Caruso, J.J. (1985). The role of teacher advisors in improving writing instruction. Journal of Staff Development, 6(2) 67-73.

Crosswhite, J., Dossey, J., Swafford, J., McKnight, C., & Cooney, T. (1985). Second International Mathematics Study: Summary report for the United States. Champaign, IL: Stipes Publishing.

Dossey, J.A., Mullis, I.V.S., Lindquist, M.M., & Chambers, D.L. (1988). The mathematics report card: Are we measuring up? Trends and achievement based on the 1986 national assessment. Princeton, NJ: Educational Testing Service.

Glassberg, S., & Oja, S.N. (1981). It's a developmental model for enhancing teacher's personal and professional growth. Journal of Research and Development in Education, 14(2), 58-70.

Havelock, R.G. (1968). Dissemination and translation roles. In T.L. Ieidell & J.M. Kitchell (Eds.), Knowledge, production and utilization in Education Administration (pp. 74-119). Eugene: University of Oregon, Center for the Advanced Study of Educational Administration.

Holmes Group. (1986). Tomorrow's teachers: A report of the Holmes Group. East Lansing, MI: Author.

Howsam, R.B. (1967). Effecting needed changes in education. In E.L. Morphet & C. O'Ryan (Eds.), Planning & effecting needed changes in education (pp. 65-81). Denver, CO: Publishers Press.

Joyce, B., & Showers, B. (1988). Student achievement through staff development. New York, NY: Longman.

Knowles, M.S. (1984). Androgyny in action. San Francisco: Jossey-Bass.

McKight, C.C., Crosswhite, F.J., & Cooney, T.J. (1987). The underachieving curriculum: Assessing U. S. school mathematics from an international perspective. Champaign, IL: Stipes.

Madsen-Nason, A. (1988). A teacher's changing thoughts and practices in ninth grade general mathematics classes: A case study (Doctoral dissertation, Michigan State University, 1988). Dissertation Abstracts International, 50, 666A.

Mathematical Sciences Education Board & the National Research Council. (1990). Reshaping school mathematics: A philosophy and framework for curriculum. Washington, DC: National Academy Press.

National Council of Teachers of Mathematics. (1980). An agenda for action: Recommendations for school mathematics of the 1980s. Reston, VA: Author.

National Council of Teachers of Mathematics. (1989). Curriculum and evaluation standards for school mathematics. Reston, VA: Author.

National Council of Teachers of Mathematics. (1991). Professional standards for teaching mathematics. Reston, VA: Author.

National Research Council. (1989). Teaching. Everybody counts: A report to the nation on the future of mathematics education. Washington, DC: National Academy Press.

Oja, S.N. (1980). Adult development is implicit in staff development. Journal of Staff Development, 1(2), 7-56.

Seiber, S.D., Louis, D.S., & Metzger, L. (1972). Evaluation of pilot state dissemination programs. New York: Columbia University, Bureau of Applied Social Research.

Showers, B. (1983a, April). Coaching: A training component for facilitating transfer of training. Paper presented at the annual meeting of the American Educational Research Association, Montreal, Quebec, Canada.

Showers, B. (1983b). Transfer of training: The contribution of coaching. Eugene: University of Oregon, Center for Educational Policy and Management.

Showers, B. (1985a). Teachers coaching teachers. Educational Leadership, 42(7), 44-48.

Showers, B. (1985b). Teachers coaching teachers. Educational Leadership, 43(8), 43-48.

Tallerico, K.M. (1987). Building level staff development: A personal account of peer helping peer. Journal of Staff Development, 8(1), 32-35.

Appendix

Mathematics Support Teacher Reading List

Mathematics Support Teacher Readings

Support Teacher Role

Cummings, C. (1980). Motivation. In C. Cummings, Teaching makes a difference. Edmonds, WA: Teaching.

Erickson, M. (1982). Learning to read educational research. Phi Delta Kappan, 64, 276-277.

Fenstermacher, G.D., & Soltis, J.F. (1986). The teacher as ... In G.D. Fenstermacher & J.F. Soltis, Approaches to teaching (pp. 1-9). New York: Teachers College Press.

Garmston, R.Y. (1987). How administrators support peer coaching. Educational Leadership, 44 (5), 18-26.

Glickman, C.D. (1985). Observing skills. In C.D. Glickman, Supervision of Instruction (pp. 207-231). Boston: Allyn & Bacon.

Guskey, T.R. (1986). Staff development and the process of teacher change. Educational Researcher, 15 (5), 5-12.

Johnson, D.W., & Johnson, R.T. (1987). Research shows the benefits of adult cooperation. Educational Leadership, 45 (3), 27-35.

Meyers, Y. (1981). Mental health consultation. In J.C. Conoley (Ed.), Consultation in schools: Theory, Research, Procedures (pp. 35-53). New York: Academic Press.

Neubert, G.A., & Bralton, E.C. (1987). Team coaching: Staff development side by side. Educational Leadership, 44 (5), 29-32.

Servatius Y.D., & Young S.E. (1985). Implementing the coaching of teaching. Educational Leadership, 42 (7), 50-53.

Showers, B. (1985). Teachers coaching teachers. Educational Leadership, 42 (7), 44-48.

Mathematics Teaching

Anderson, R.D. (1982). Arithmetic in the computer/calculator age. Paper presented at the National Academy of Sciences Task Force Meeting on Mathematics Curriculum K-12 in Washington, DC.

Madsen-Nason, A., & Lanier, P.E. (1986). From a computational to a conceptional orientation: An instructional evolution of Pamela Kaye and her general mathematics class (Research Series No. 172). East Lansing: Michigan State University, Institute of Research on Teaching.

Improving Instruction

Edwards, S.A., & Barnes, S. (1985). A research-based staff development that works. Educational Leadership, 42 (7), 54-56.

Harvard Graduate School of Education (1987). Teaching for understanding in the age of technology (Position Paper). Cambridge, MA: Author.

Johnson, D.W., & Johnson R.T. (1975). Structuring cooperative learning. Learning together and alone: Cooperative, competitive and individualistic learning (pp. 43-63). Englewood Cliffs, NJ: Prentice Hall.

Johnson, D.W., & Johnson, R.T. (1975). Student acquisition of collaborative skills. Learning together and alone: Cooperative, competitive and individualistic learning (pp. 105-123). Englewood Cliffs, NJ: Prentice Hall.